Assessment of different gutta-percha brands during the filling of simulated lateral canals

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Abstract

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Aim To compare the ability of five different commercially available gutta-percha points to fill simulated lateral canals when subjected to warm vertical compaction.

Methodology Fifty clear plastic teeth with a lateral canal in each third of the root were used. All teeth were filled using warm vertical compaction. Backfilling was completed with a sealer and the same gutta-percha point used during the apical condensation. After this, they were horizontally sectioned using a diamond disc adapted to a low-speed saw. The resulting sections were embedded in epoxy resin. The extent of gutta-percha and sealer filling were measured in each lateral canal using an IMAGE-PRO 4.0 software system. The voids in each canal were measured using the same system. Data were ranked and analysed using the Kruskal–Wallis statistical test.

Results The mean percentage of the three lateral canals filled with gutta-percha and sealer were respectively: Konne (68.23% and 24.50%), Analytic (67.90% and 25.28%), Obtura (63.80% and 29.60%), Tanari (49.42% and 45.86%) and Dentsply (44.60% and 47.05%). There was significantly ($P < 0.05$) more gutta-percha in the lateral canal filled with Analytic™, Obtura™ and Konne™ points than with Tanari™ and Dentsply™ points.

Conclusions The brand of gutta-percha cone had an influence on the length of filling within lateral canals. This may be a reflection of the chemical formulation of the gutta-percha points.

Keywords: flow, gutta-percha, lateral canals.

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Introduction

The major objective of root canal treatment is to prevent or cure apical periodontitis by cleaning, shaping and filling the root canal space. The root canal system has a complex anatomy, characterized by the occurrence of curvatures, accessory and lateral canals, deltas and isthmuses (Schilder 1967). Root canal filling procedures should fill the main root canal and all accessory canals (Weine 1984, Goldberg *et al.* 2001).

A number of studies have reported that the lateral canals are present in a substantial number of teeth. For example, Rubach & Mitchell (1965) found lateral canals in 45% of 74 teeth studied, most of them located in the apical third. De Deus (1975) demonstrated lateral canals in 27.4% of 1140 teeth: 17% situated in the apical third, 8.8% in the middle and 1.6% in the coronal third.

Accessory and lateral canals provide a potential route between the root canal space and periodontal tissues for remaining bacteria (Stallard 1972); they can also harbour residual pulp tissue. In teeth with necrotic

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pulp, bacteria and tissue debris enclosed in accessory and lateral canals are difficult to eliminate by conventional endodontic instrumentation. For these reasons three-dimensional root canal filling becomes particularly important (Schilder 1967).

The warm vertical compaction of gutta-percha has the potential to produce a complete filling of the root canal space including lateral canals (Schilder 1967, Goldberg *et al.* 2001). Reader *et al.* (1993) and DuLac *et al.* (1999) reported that warm vertical compaction technique filled lateral canals with gutta-percha. On the contrary, cold lateral compaction cannot move gutta-percha into canal irregularities (Reader *et al.* 1993). The System B endodontic heat source unit (EIE/Analytic, Redmond, WA, USA) has been designed to fill the root canal system with a single continuous wave of thermoplasticized gutta-percha (Buchanan 1996).

The ability of the filling material to flow into lateral canals has been widely reported in the literature (Tagger & Gold 1988, Reader *et al.* 1993, Wolcott *et al.* 1997, DuLac *et al.* 1999, Goldberg *et al.* 2001). Some studies have reported the use of different nonstandardized points during warm vertical compaction of gutta-percha (Goldberg *et al.* 2001, Wu *et al.* 2001, Bowman & Baumgartner 2002, De-Deus *et al.* 2004). However, there are no reports comparing different brands of gutta-percha points and their ability to fill lateral canals and other irregularities.

The purpose of this *ex vivo* study was to compare the percentage of lateral canals in different thirds of the main canal filled by five commercially available medium gutta-percha points when using a warm vertical compaction technique: Dentsply^{TM} (Dentsply Ind. Comércio Ltda, Petrópolis, Brazil), Tanari^{TM} (Tanariman Ltda, Macapuru, Brazil), Konne^{TM} (Konne Ind e Comércio Ltda, Belo Horizonte, Brazil), Obtura Spartan^{TM} (Precise Dental International S.A., Jalisco, Mexico) and Analytic Endodontics^{TM} (Analytic Endodontics, Orange, CA, USA).

Materials and methods

Fifty clear plastic teeth (Advanced Endodontics, Santa Barbara, CA, USA) with standardized simulated single canals were used (Fig. 1). The teeth had a single cervical, middle and apical lateral canal, each being 0.2 mm in diameter. The lateral canals were located at 2, 5 and 7 mm from the apex respectively. The apical, middle and cervical lateral canal lengths were 1.1, 1.2 and 1.2 mm respectively. The lengths of the lateral canals were recorded using a digital video camera (LG Colour Camera CCD, Seoul, Korea) through a stereomicroscope at a magnification of 50× (Lambda Let, Hong Kong, China). They were then measured using computer-imaging software (Imagelab 2.3, São Paulo, Brazil). Each tooth was 22 mm in length. The teeth were covered with aluminium tape leaving the access to the root canal open and they were randomly separated into five experimental groups ($n = 10$).

The apical foramen was penetrated with a size 20 K-file (Dentsply Maillefer, Ballaigues, Switzerland). The working length was determined by subtracting 1 mm from the tooth length and the canals

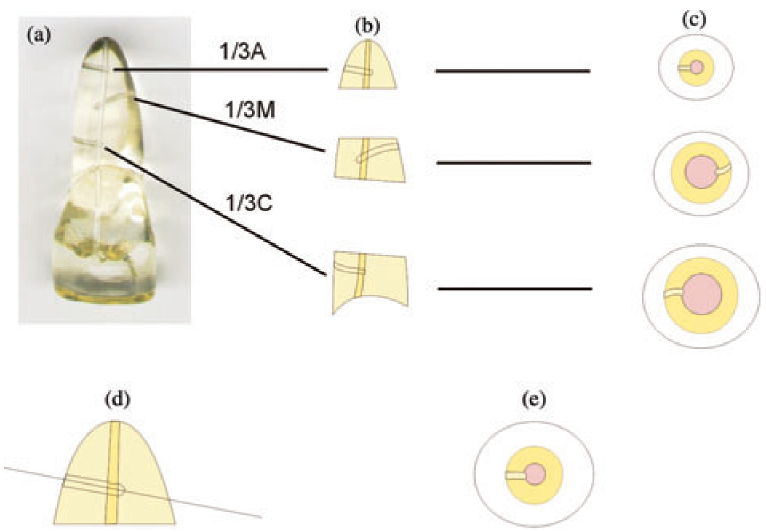

Figure 1 (a) Plastic tooth. (b) Cross-section. (c) Ambition in epoxy resin. (d) Specimen polishing. (e) Specimen ready for analysis.

instrumented using K-files (Dentsply Maillefer) until a size 50 K-file reached the working length (Wolcott *et al.* 1997). The coronal and middle thirds of each canal were enlarged with Greater Taper files sizes 12 and 10 (Tulsa Dental Products Dentsply, Tulsa, OK, USA) and Gates–Glidden drills sizes 3 and 2 (Dentsply Maillefer). Finally a step back preparation with sizes 55 and 60 K-file was performed. After each instrument, the canal was irrigated with 2 mL of distilled water using a 27-gauge needle. The canals were dried with absorbent paper points and canal patency was verified using a size 20 K-file (Goldberg *et al.* 2001).

All teeth were filled using warm vertical compaction with the Continuous Wave of Condensation technique (System B) using one or other of five different brands of gutta-percha point: G1 ($n = 10$) Dentsply™; G2 ($n = 10$) Tanari™; G3 ($n = 10$) Konne™; G4 ($n = 10$) Obtura Spartan™ and G5 ($n = 10$) Analytic Endodontics™ (Table 1).

Medium points were standardized using an endodontic calibration ruler (Dentsply Maillefer) to ensure the size 50 tip corresponded to the apical stop established by the master apical file (Wolcott *et al.* 1997). A medium plugger was selected to bind 5–7 mm from the apical stop. The sealer (Grossman, Dentsply, Petrópolis, Brazil) was prepared according to the manufacturer's instruction and was applied lightly to each gutta-percha point and placed to within 1 mm of the working length. The heat source was set to 200 °C. The tip of the plugger was driven through the master cone with a single motion to a point 5–7 mm short the working length. Whilst pressure on the plugger was maintained, the button on the heating system was released, and pressure was maintained on the plugger until the apical mass of the gutta-percha had cooled (5–10 s). Then the switch was reactivated for a short burst of heat (1 s) to release the plugger and the surplus of gutta-percha. Once the apical segment had been filled, the coronal portion of the canal was filled using the same system with modified temperatures (100 °C). The backfilling cone was prepared at the same time as the original medium nonstandardized master cone. Sealer was used with the backfilling cone, which was seated in the canal. The cone was warmed without pressure to soften it, followed by a sustained pressure to allow the cone to adapt to the walls and cool in the canal. The teeth were then stored in humidified air (100% of relative humidity) at 37 °C for 2 weeks (DuLac *et al.* 1999).

After that, each sample was sectioned with an Isomet precision saw (Buhler Ltd, Lake Bluff, NY, USA) using a diamond disc (Ø 125 mm × 0.35 mm × 12.7 mm – 330 °C) at the low speed placed perpendicular to the main canal at 3, 6 and 8 mm from the apex. During this procedure, the samples were constantly irrigated with water in order to prevent overheating. Subsequently, the sections of each sample were embedded in an epoxy resin cylinder (Arazyn 1.0; Ara Química, SP, Brazil) to make their manipulation simpler. The margins adjoining the epoxy resin and tooth were sealed with cyanoacrylate (Super bonder Gel; Lockite, Itapevi, SP, Brazil).

Specific sandpaper (DP-NETOT 4050014; Struers, Ballerup, Denmark) for materialographic preparation was used. The specimens were polished prior to their examination under the microscope using a diamond paste of 4–1 μm roughness (SAPUQ 40600235; Struers) and sandpaper size 1000 to avoid gutta-percha deformation and to obtain a surface that was free from scratches and deformities resulting in a highly reflective surface (De-Deus *et al.* 2004).

The samples were examined under a microscope (Axiscoppe; Carl Zeiss Vision Gmbh, Hallbergmoos, Germany). Photographs were taken of each sample at 50× magnification. The images were recorded (Tagged Image File Format) and measured in millimetres, with an accuracy of 0.01 mm, using the IMAGE-PRO 4.0 system (Media Cybernetics, Silver Spring, MD, USA). The linear percentage of gutta-percha, sealer and voids present in each lateral canal was computed from measurements made of the total length of the lateral

Table 1 Medium-size dental gutta-percha points selected for study

Product	Manufacturer	Batch number	Gutta-percha content (%)
Dentsply	Dentsply Indústria e comércio Ltda, Petrópolis, R.J, Brazil	55448	14.5[a]
Tanari	Tanariman Ind. Ltda, Macapuru, Amazonas, Brazil	011001G	15.6[a]
Analytic	Analytic Endodontics, Orange, CA, USA	110698	20.4[a]
Obtura Spartan	Precise Dental International S.A., Jalisco, Mexico	9693A	17.7[a]
Konne	Konne Indústria e Comércio de materiais odontológicos, Belo Horizonte, MG, Brazil	–	18.9[a]

[a]Results obtained from Gurgel-Filho *et al.* (2003).

Table 2 Percentage of lateral canals occupied by gutta-percha, sealer and voids

	Gutta-percha (mean % ± SD)			Sealer (mean % ± SD)			Voids (mean % ± SD)		
Brand	Apical	Middle	Cervical	Apical	Middle	Cervical	Apical	Middle	Cervical
Analytic	7.73 ± 7.1	98.90 ± 2.4[a]	96.97 ± 5.2	73.41 ± 6.9	0[a]	2.42 ± 5.4	18.83 ± 8.7	0.96 ± 2.0	0
Konne	6.71 ± 6.2	98.23 ± 4.4[a]	99.67 ± 1.0	73.48 ± 22.4	0[a]	0	20.34 ± 18.1	1.42 ± 4.4	0
Obtura	8.92 ± 6.7	88.15 ± 14.6[a]	94.36 ± 9.2	70.47 ± 9.3	12.69 ± 16.1[a]	5.64 ± 9.2	22.39 ± 13.9	0	0
Tanari	7.23 ± 4.2	49.01 ± 13.7[b]	92.03 ± 7.5	78.11 ± 12.5	51.24 ± 13.8[b]	8.23 ± 7.7	15.58 ± 12.5	0	0
Dentsply	2.77 ± 4.4	37.53 ± 14.5[b]	93.49 ± 6.9	72.01 ± 23.5	62.53 ± 13.0[b]	6.61 ± 7.2	23.80 ± 23.1	0	0

[a,b]Significant statistical differences using the Kruskal–Wallis statistical test ($P < 0.05$).

canal and the length filled by the gutta-percha. One investigator, unaware of the gutta-percha brand used, made all measurements. The Kruskal–Wallis statistical test was applied with 5% significance.

Results

The percentage of gutta-percha, sealer and voids at each of the three levels, for all five brands analysed, are shown in Table 2. The movement of gutta-percha into the cervical canal (92.0–100%) was, in general, higher than that for the middle (37.5–99%) and apical canals (2.7–9.0%). The mean values of voids were 24.17% and 0.4% in apical and middle canals respectively. More than 92% of cervical lateral canals were filled completely, independent of the brand of cone (Table 2).

There was no statistically significant difference ($P > 0.05$) between the five brands in terms of gutta-percha, sealer and voids noted at apical and cervical thirds as shown in Table 2.

There was more gutta-percha present in the middle third canals filled using Analytic™, Obtura™ and Konne™ than Tanari™ and Dentsply™ as shown in Table 2 ($P < 0.05$). There were no statistical significant differences between Dentsply™ and Tanari™, and amongst Analytic™, Obtura™ and Konne™ brands in regard to the middle third lateral canals ($P > 0.05$) (Table 2).

Discussion

The purpose of this study was to compare the movement of material inside lateral canals filled with endodontic sealer and one or other of five different types of gutta-percha brands of cones; remaining voids were also assessed. The limitations of the epoxy resin teeth are obvious and their use did not allow an exact replica of extracted human teeth. Therefore, smear layer removal and the patency of lateral canals were not considered. The main advantage of the plastic teeth was that they provided a standardized sample of similar size and minimized the variable effects of instrumentation technique.

The endodontic sealer can flow into the root canal irregularities and fill minor discrepancies between the root canal wall and core-filling materials (Gutmann & Witherspoon 1998). Schilder (1967) reported that using a warm vertical condensation technique, narrow lateral canals are filled with only the sealer, which he considered to be more advantageous than leaving them unfilled.

In this study, a System B plugger was selected and positioned 7 mm from the apical stop (Buchanan 1996), this was 5 mm from the apical lateral canal and 2 mm from the middle lateral canal. Bowman & Baumgartner (2002) reported enhanced gutta-percha reproduction when the System B plugger was fitted 3 mm from working length. This could explain the low percentage of lateral canals filled by gutta-percha in the apical third independent of the brand used. DuLac *et al.* (1999) using resin blocks with three lateral canals reported that most of the apical lateral canals were filled with only sealer. This was also observed in the apical third of the present study. The diameter of the lateral canals was approximately size 20, which is compatible with the size of lateral canals (0.15 mm) reported in previous studies (Vertucci & Anthony 1986).

The greatest movement of filling material was observed in the middle lateral canal. This result shows that there may be better gutta-percha flow when the heat source is applied within 3-mm of the gutta-percha points. Canals filled with Dentsply™ and Tanari™ points had significantly ($P < 0.05$) less gutta-percha in the middle lateral canals than the Analytic™, Obtura™ and Konne™ (Figs 2 and 3). There was no statistically significant difference between Dentsply™ and Tanari™ brands. The results confirmed that different brands might indeed differ in their ability to flow into lateral canals. This property

Figure 2 Representative sample of Dentsply at apical, middle and coronal third. Note the length of gutta-percha, sealer and voids (50×).

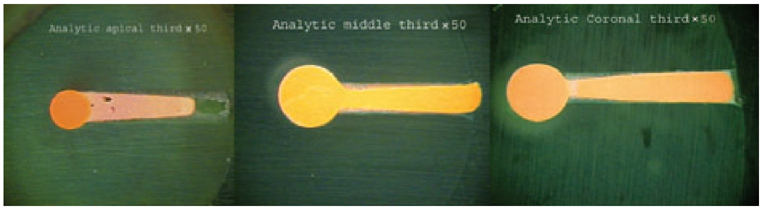

Figure 3 Representative sample of Analytic at apical, middle and coronal third. This brand produced one of the best quality (50×).

could be associated with the organic fraction, i.e. gutta-percha polymer (Table 1) (Gurgel-Filho *et al.* 2003). A low percentage of gutta-percha can decrease the flow rate (Zuolo & Imura 1998). Current gutta-percha points are composed of organic (gutta-percha polymer and wax/resins) and inorganic components (zinc oxide and barium sulphate). Recently, the chemical and X-ray analyses of these brands were completed by Gurgel-Filho *et al.* (2003). The results showed that Dentsply™ and Tanari™ contained relatively low percentages of gutta-percha polymer, 14.5% and 15.6% respectively, which could result in reduced plasticity (Gutmann & Witherspoon 1998). On the contrary, Konne contained 18.9%, Obtura 17.7% and Analytic 20.4% of gutta-percha polymer. These results are important, not only when considering the filling of lateral canals, but also for filling of wide canals and other anatomical irregularities.

The findings showed that most of the cervical lateral canals were filled with gutta-percha. The high percentage of cervical lateral canals filled by gutta-percha could be explained by the proximity of the heated System B plugger used during the filling procedures, which produced enough warmth to soften the gutta-percha, regardless of the brand used. All the main canals were completely filled with compacted warm gutta-percha.

Conclusion

Gutta-percha and sealer penetration into lateral canals ranged from 68.23% to 44.60% and from 24.50% to 47.05% respectively. The mean percentage of the three lateral canals filled with gutta-percha and sealer were respectively: Konne (68.23% and 24.50%), Analytic (67.90% and 25.28%), Obtura (63.80% and 29.60%), Tanari (49.42% and 45.86%) and Dentsply (44.60% and 47.05%). The differences between brands may reflect their composition.

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